Rocky Mountains
Southwest
Great Plains

Research Note RM-432

November 1983

USDA Forest Service

Rocky Mountain Forest and Range Experiment Station

Distribution of Pandora Moth Egg Masses and First Stage Larvae

J. M. Schmid,[1] D. D. Bennett,[2] and M. Andrews[2]

The distribution of pandora moth egg masses and larvae was examined near Jacob Lake, Arizona. Egg mass numbers were not significantly different among aspects nor, in general, among trees but the number of first stage larvae were greater on the east and south sides than on the north side. Egg mass counts were significantly greater in stands severely defoliated by the previous larval generation than they were in stands severely defoliated by two previous larval generations or in stands with no previously significant defoliations. This information is discussed in relation to sampling.

Keywords: Pandora moth, *Coloradia pandora*

Introduction

The pandora moth, *Coloradia pandora* Blake, occurs in outbreak proportions so rarely that little information has been developed on the distribution of its life stages. Schmid et al. (1982a) sampled the vertical distribution of egg masses on two sizes of trees. There were significantly fewer egg masses per branch and per 30-cm unit of branch, in the upper crowns of 17- to 26-m tall trees, than in the lower crowns. On trees 8 to 15 m tall, egg masses per branch and per 30-cm unit of branch were generally constant throughout the height of the crown. Schmid et al. (1982b) observed that more late instars were present on the north sides of 8- to 17-m tall trees than on the other three aspects, and number of larvae on approximately 14-m tall trees increased with height but were too variable to indicate a significant trend. Because the distribution of egg masses and first stage larvae with respect to aspect was unknown, this information was gathered to develop sampling methods to be used to determine population levels and mortality during suppression projects.

[1]*Research Entomologist, Rocky Mountain Forest and Range Experiment Station. Station headquarters is in Fort Collins, in cooperation with Colorado State University.*

[2]*Entomologists, Forest Pest Management, USDA Forest Service, Southwestern Region, Albuquerque, N. Mex.*

Methods

The 2-year life cycle of the pandora moth and the general area of infestation are briefly described by Schmid et al. (1982a, 1982b). Egg mass counts were made within areas defoliated by previous generations and in surrounding stands where no significant defoliation was evident. Larval counts were made along Forest Service roads 257 and 482, northeast of Jacob Lake, Arizona. The areas along these two roads were defoliated in 1981 but not in 1979.

During August 21-29, 1982, four locations in the infested area were sampled to determine the aspectual distribution of egg masses. Trees in each area were randomly selected, except that each tree had a well-developed crown with well-foliated branches on all cardinal directions. Two sizes of trees were sampled to determine if aspectual egg mass counts varied between tree sizes. Trees along road 246 and highway 89A had been defoliated by two previous generations; trees along roads 257 and 482 had been defoliated only by the previous generation.

One branch tip was pruned from each cardinal aspect of host sample trees (table 1). Samples were drawn from 7 m to 10 m aboveground. Egg masses were counted on the foliage and stems of each shoot, beginning with the terminal shoot and working toward the base of the

Table 1.—Summary statistics for 1982 pandora moth egg mass sampling near Jacob Lake, Arizona[1]

Location	Date sampled	Height of trees	Number of trees
FS Road 257	21, 22 August	>20 m	26
FS Road 246	23, 24 August	>20 m	21
Highway 89A	24-27 August	>20 m	10
	24-27 August	7-12 m	10
FS Road 482	28, 29 August	7-12 m	14
	28, 29 August	>20 m	14

[1]*North, east, south, and west aspects were sampled on each tree.*

branch. A shoot was defined as a live bud surrounded by at least six needle fascicles, the needles being 5 cm or more long (fig. 1A). Shoots with fewer fascicles or shorter needles (fig. 1B) were not counted as shoots. Some shoots were essentially stemless; others had stems 30 cm or more long. Because of the diverging nature of pine branches, egg masses were counted only on the first 13 shoots of each sample. When working backward from the terminal shoot along the primary stem, lateral branches with two or more shoots were commonly encountered. Therefore, a decision had to be made as to which shoot on the lateral branch sequentially constituted the "next shoot." The terminal shoot on the lateral branch was chosen, and subsequent sequential shoots were those inward from the terminal (fig. 2). The number of egg masses per the first shoot, first three shoots, first five shoots, etc. were tallied and used in analysis of variance testing for significant variation among trees and aspects ($\propto$ = 0.05).

During September 27-29, 1982, egg mass counts were made to determine the incidence of egg masses in previously defoliated areas and in surrounding undefoliated stands. Forty-one plots were installed as described by Bennett (1982). Seven plots (1-7) were in the area severely defoliated in 1979 and 1981. Plots 8-14 were in the area severely defoliated in 1981. Plots 15-41 were in undefoliated stands adjacent to the previously defoliated areas.

One branch tip was pruned from each sample tree, between 7 and 12 m aboveground, without regard to aspect. Three types of egg mass counts were taken: number per branch, per nine shoots, and per 100 cm of branch. Numbers per branch were recorded because the 1980 egg mass survey by Forest Pest Management used this basis, and the 1982 survey sought to compare the 1980 and 1982 counts. Analysis of the August 1982 egg mass data indicated nine shoots would be a practical number to examine; therefore, counts were also recorded on this basis. Generally, the number of shoots per branch usually exceeded nine; therefore, the number of egg masses per branch was greater than the number per nine shoots. Because branch length ranged from 76 cm to 196 cm and the analysis of the 1982 egg mass data indicated the number of egg masses increased linearly with increasing numbers of shoots, egg masses were recorded per 100 cm of branch length to

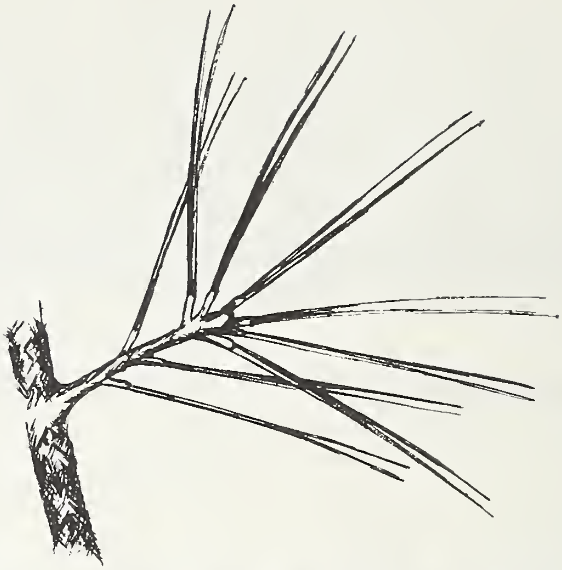

Figure 1a.—Satisfactory shoot composed of six or more needle clusters of adequate needle length.

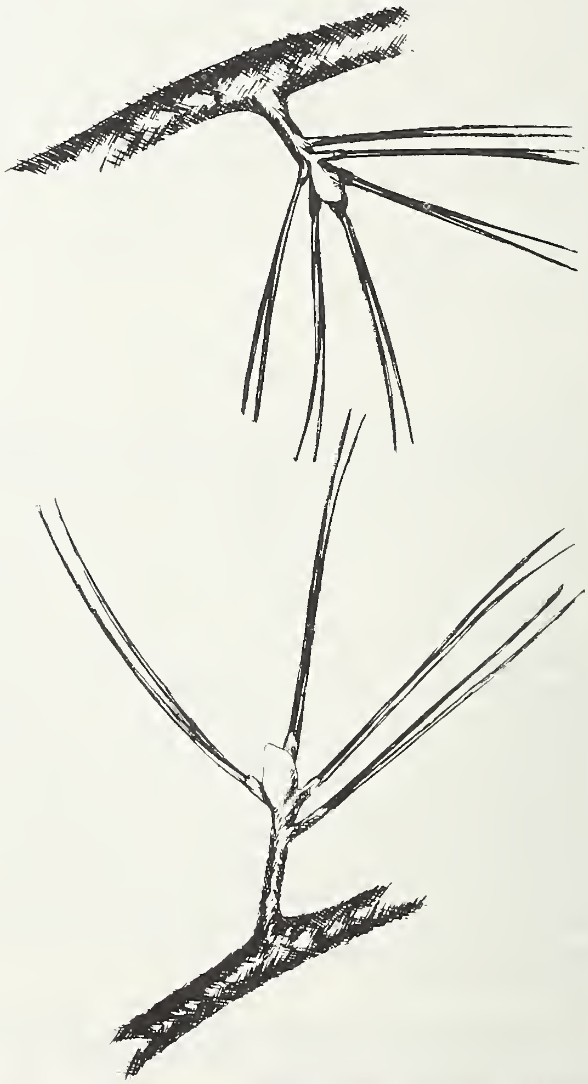

Figure 1b.—Unsatisfactory shoots rejected because needles too short or the number of needle clusters less than six.

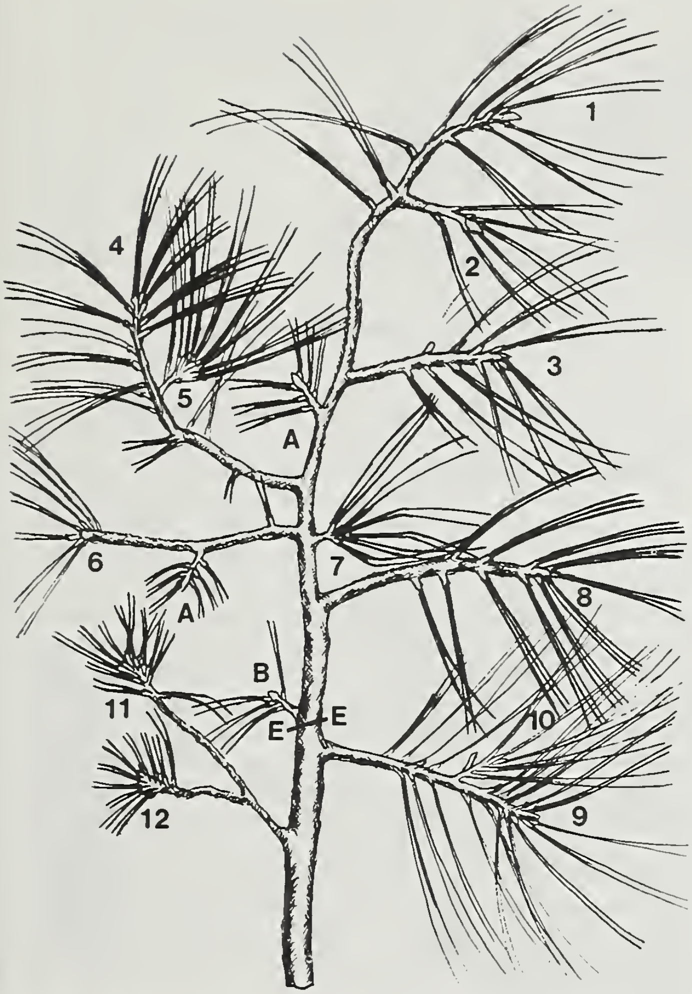

Figure 2.—Sample branch depicting the numbering of shoots for use in the 9-shoot method. Some shoots are not included because the needles are short (A) or the number of needle clusters is less than six (B). Shoot 9 terminates at the junction of its stem and the stem of shoot 10. Egg masses are counted on the first nine shoots which includes all the stems and needles from the tip of the branch to the line E-E (considered the end of shoot 8) plus shoot 9.

reduce the variability contributed by variable branch length. The number of egg masses per branch, per nine shoots, and per 100 cm of branch were subjected to analysis of variance testing for significant variation associated with plots (α = 0.05).

During October 19-21, 1982, prespray larval counts were made as part of insecticide evaluations. Five rectangular-shaped areas, each about 8 ha, were established along both Forest Service roads 257 and 482. Samples were drawn from 24 trees within each of the 10 areas. Two branch tips were collected from each tree, from opposite sides of the crown—either north and south or east and west. Branches were taken from 7 to 12 m aboveground, and larval counts were made on nine shoots as previously described. Counts along each road were pooled and were subjected to analysis of variance testing for significant variation among trees and aspects (α = 0.05).

Results and Discussion

Egg Mass Distribution Among Trees and Crown Aspects

Mean numbers of egg masses were significantly different among trees on the 246 plot and among the smaller trees on the 89A plot, but trees were not a significant factor on the other plots. Because the significant tree variation occurred within areas severely defoliated by two successive generations, some trees may have produced more foliage than others after the severe defoliation, and, therefore, may have been more suitable for ovipositing females.

Mean numbers of egg masses were not significantly different among aspects within the same tree size for specific locations (table 2), which suggests samples can be drawn without regard to aspect.

Mean numbers increased linearly with an increasing number of shoots and did not level off within the first 13 shoots sampled. The terminal nine shoots were selected for future sampling, because they provided adequate foliage and were generally small enough to be gathered into a basket on a pole pruner.

Egg Mass Distribution in Previously Defoliated and Undefoliated Areas

Egg mass counts were significantly greater in the areas defoliated by the previous generation (plots 8-14) than in areas severely defoliated by two previous generations (plots 1-7) or in essentially undefoliated areas (plots 15-41) (table 3). More egg masses in areas severely defoliated by only the previous generation may occur because adult densities are greatest there and females oviposit more eggs in the area where they emerge. Stands severely defoliated by two previous generations may have declining adult numbers.[3] Numbers of egg masses are probably less in essentially undefoliated stands, because adults are immigrating into such stands and the density of ovipositing females is

[3] *Schmid, J. M. Emergence of adult pandora moths in Arizona. Manuscript submitted to Great Basin Naturalist for publication.*

Table 2.—Mean number (± standard deviation) of egg masses per nine shoots by aspect,[1] Kaibab National Forest, Jacob Lake, Arizona, August 1982

Location	Tree height	Aspect			
		North	East	South	West
FS Road 246	>20 m	4.2 ± 2.9	4.5 ± 3.0	4.1 ± 3.5	5.4 ± 3.5
FS Road 257	>20 m	4.8 ± 3.1	4.0 ± 2.6	3.7 ± 2.9	4.3 ± 3.0
FS Road 482	7-12 m	7.4 ± 4.0	8.4 ± 4.2	6.6 ± 3.4	5.4 ± 3.5
FS Road 482	>20 m	5.3 ± 3.7	5.4 ± 3.7	5.6 ± 4.5	4.0 ± 3.1
Highway 89A	7-12 m	6.3 ± 3.6	6.1 ± 3.9	5.4 ± 5.8	4.4 ± 3.8
Highway 89A	>20 m	5.0 ± 3.1	3.1 ± 3.1	4.8 ± 2.7	4.8 ± 4.0

[1] *Within the same tree size for a specific location, means were not significantly different (α = 0.05).*

Table 3.—Mean number (± standard deviation) of pandora moth egg masses per branch, per nine shoots, and per 100 cm of branch, for selected grouping of plots, Kaibab National Forest, Jacob Lake, Arizona, September 27-29, 1982[1]

Defoliation class		Branch	Nine shoots	100 cm of branch
2 years of defoliation	(Plots 1-7)	7.0 ± 5.9b	3.6 ± 3.5b	6.3 ± 5.6b
1 year of defoliation	(Plots 8-14)	13.5 ± 10.6a	7.5 ± 6.4a	11.4 ± 9.3a
Nondefoliated	(Plots 15-41)	5.8 ± 5.1b	3.0 ± 3.0b	4.8 ± 4.3b

[1] *Within each type of egg mass count, means followed by the same letter are not significantly different (∝ = 0.05).*

less. Furthermore, females probably deposit an egg mass before initiating their dispersal flight. Therefore, their oviposition in undefoliated stands is not the full complement of eggs.

The egg mass distribution pattern within defoliated and undefoliated stands has several implications for future sampling and population trend predictions. First, a comprehensive defoliation survey must be completed immediately following the most recent defoliation period so that the extent of the defoliation can be mapped. The location of plots during the subsequent egg mass survey will depend on the defoliation survey. Second, plots for a future egg mass survey should be distributed in much the same manner as in Bennett's 1982 survey (i.e., adequate numbers of plots taken from each area representing the different years of defoliation). Third, the population trend should be observed to determine if the population begins to collapse in phases corresponding to the age of defoliated areas, or if the population uniformly collapses throughout the entire infested area.

First Instar Distribution Among Aspects

The mean number of larvae per nine shoots was significantly greater on the south and east sides of sample trees than on the north sides (table 4). This pattern may result from the dispersal of larvae from the more northerly to the southerly sides of the trees. Larval survival is enhanced there, because the southerly sides are warmer during the winter.

Bias in selection of trees for egg mass sampling or significant early larval mortality could have created the change in aspectual significance from the egg stage to the larval stage. However, these possibilities probably are insignificant in this situation. The egg mass sample trees along Forest Service roads 257 and 482 were in the same areas as those used for larval sampling, and trees for both egg mass and larval sampling generally had the same type of crown. In addition, substantial larval mortality was not observed between the egg mass and larval sampling periods. Therefore, the significant difference in larval numbers associated with aspect is unlikely to have resulted from mortality associated with only the north sides. Furthermore, it was not uncommon to observe larvae, which had hatched from egg masses on the bole, moving upward on the bole toward branches 5 or more meters away. Thus, it is conceivable that larvae moved from the north side to the south side.

Table 4.—Mean number of larvae per nine shoots, by aspect, Jacob Lake, Arizona, October 1982[1]

Aspect	FS Road 257	FS Road 482
North	14.1a	13.6a
East	32.1bc	38.5c
South	40.2c	33.6bc
West	26.0ab	21.5ab

[1] *For each road, means followed by the same letter are not significantly different (∝ = 0.05).*

The differential concentration of larvae associated with aspect indicates that first instar samples must be drawn from all crown aspects to obtain an estimate for the numbers within the crown. If larval mortality is evaluated during population dynamics or insecticide studies, samples either must be consistently drawn in the same manner from one aspect or from all aspects to avoid introducing error caused by differences associated with aspect.

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